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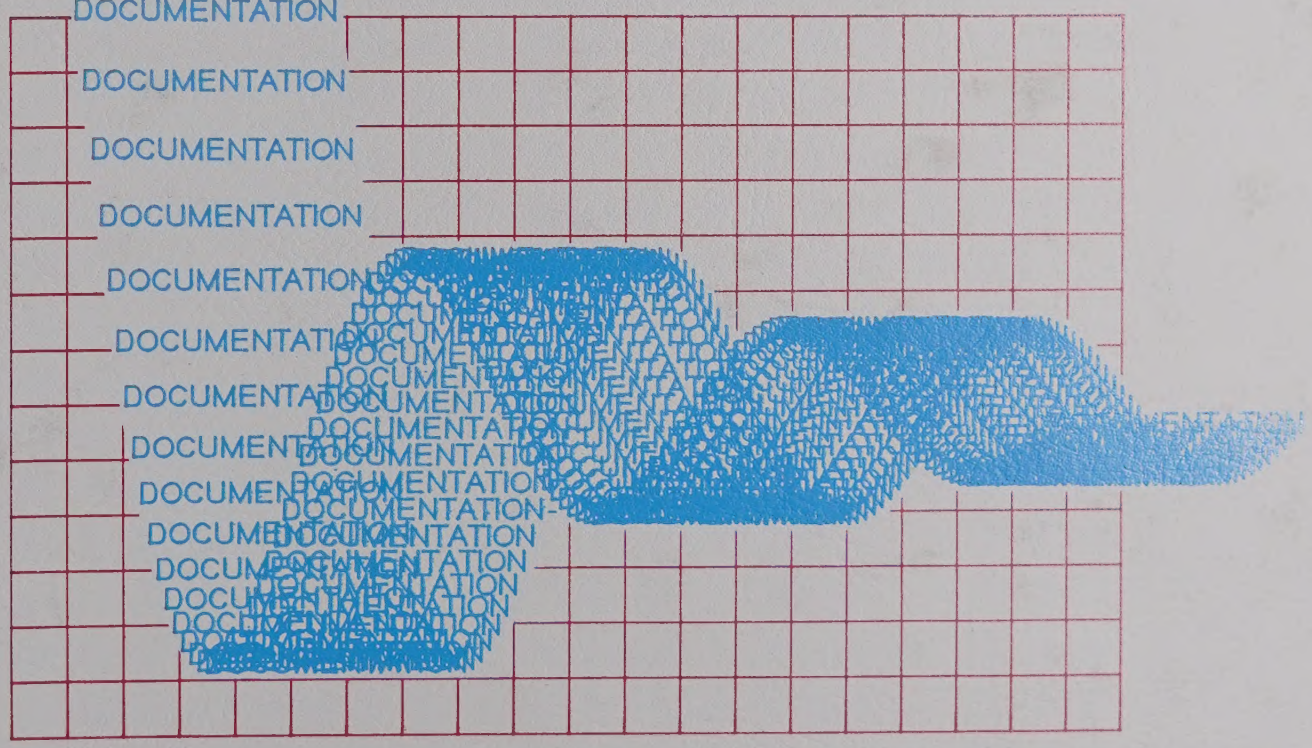

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ROHDE&SCHWARZ
Test and Measurement
Division

Operating Manual

Option SMIQB21

Bit Error Rate Test

1125.5490.02

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Inhaltsverzeichnis

1 Einbau 1.1

1.1 Anschluß 1.2

2 Manuelle Bedienung 2.1

2.1 Messung der Bitfehlerrate 2.1

2.2 Bedienmenü 2.2

2.3 Signalweg und Signalform 2.6

2.4 Meßmethode 2.7

2.4.1 PRBS-Polynome 2.9

2.4.2 Meßergebnis, Genauigkeit, Meßdauer 2.9

2.4.3 Mögliche Probleme bei der BER-Messung und Hinweise zur Lösung 2.11

3 Fernbedienung 3.1

3.1 Beschreibung der IEC-Bus-Befehle – Source:BERT-Subsystem 3.1

4 Prüfen der Solleigenschaften 4.1

4.1 Prüfablauf 4.1

4.2 Performance Test-Protokoll 4.1

Index

A

Anschluß BER 1.2
Anzeigeeinheit 2.5, 3.3

B

Bedienung
  manuell 2.1
  Fernedienung 3.1
BERT
  manuelle Bedienung 2.1
  Fernbedienung 3.1
Bitfehlerratenmessung
  Betriebsart 2.3, 3.1
  Dauermessung 2.3, 3.1
  Einzelmessung 2.3, 3.1

D

Data Enable 2.4, 3.3
Data-Enable-Eingang 2.8
Daten
  Periodenlänge 2.4, 3.2
  Polarität 2.4, 3.2
  übertragene Bits 2.2
  Unterbrechung 2.7

E

Einbau 1.1
  Option SMIQB21 – Bitfehlerratenmessung BERT 1.1
  Schlüsselwort 1.1
Eingang
  Data-Enable 2.8
  RES 2.8
Endekriterien 2.10

F

Fehler 2.2, 2.7
Fehlerbehebung 2.10

I

Integrierende Messung 2.8

M

Messung
  integrierende 2.8
Meßunterbrechung 2.10

P

Performance Test-Protokoll 4.1
Polynom
  PRBS 2.9
PRBS
  Datenerzeugung 2.7
  Polynom 2.9
Probleme und Lösungshinweise 2.11
Prüfen der Solleigenschaften 4.1

R

RES-Eingang 2.8
Restart 2.4, 3.2
Rückkoppeln 2.7

S

Signal
  Form 2.6
  Weg 2.6
Speicherumlauf 2.8
Sprungstelle 2.8
Statistik 2.9
Statusanzeigen 2.3
Synchronisierung 2.11

T

Taktrückgewinnung 2.11

U

Übernahmetakt 2.6
Unit 2.5, 3.3
Unterbrochene Zufallsfolgen 2.8

W

Wertebereich 2.9

Z

Zyklische Zufallsfolgen 2.7
Zyklischer Neustart 2.8

Technical Information
Option SMIQB21
Bit Error Rate Test

Specifications

The data supplied by the DUT are compared with a reference random bit sequence.

Pseudo-random bit sequences (PRBS)	2^9-1, 2^{11}-1, 2^{15}-1, 2^{16}-1, 2^{20}-1, 2^{21}-1, 2^{23}-1
Clock source	Supplied by DUT; a clock pulse is required for each valid bit
Clock rate	Max. 30 MHz
Synchronization time	24 clocks
Interface	9-pin sub-D connector, sub-D/BNC cable supplied with option
Data	TTL
Data enable	TTL
Clock	TTL
Restart	TTL
Setup time	10 ns
Hold time	2 ns
Polarity	Normal and inverted (data, clock, data enable)
Measurement time	Selectable through maximum number of data bits or bit errors (max. 2^{31} bits each), continuous measurement
Measurement result	BER in ppm (if selected number of data bits or bit errors is attained); status displays: not synchronized, no clock, no data

Safety Instructions

This unit has been designed and tested in accordance with the EC Certificate of Conformity and has left the manufacturer's plant in a condition fully complying with safety standards.

To maintain this condition and to ensure safe operation, the user must observe all instructions and warnings given in this operating manual.

Safety-related symbols used on equipment and documentation from R&S:

Observe operating instructions

Weight indication for units >18 kg

PE terminal

Ground terminal

Danger! Shock hazard

Warning! Hot surfaces

Ground

Attention! Electrostatic sensitive devices require special care

1. The unit may be used only in the operating conditions and positions specified by the manufacturer. Unless otherwise agreed, the following applies to R&S products:

   IP degree of protection 2X, Pollution severity 2, overvoltage category 2, altitude max. 2000 m.

   The unit may be operated only from supply networks fused with max. 16 A.

2. For measurements in circuits with voltages V_{rms} > 30 V, suitable measures should be taken to avoid any hazards.

   (using, for example, appropriate measuring equipment, fusing, current limiting, electrical separation, insulation).

3. If the unit is to be permanently wired, the PE terminal of the unit must first be connected to the PE conductor on site before any other connections are made. Installation and cabling of the unit to be performed only by qualified technical personnel.

4. For permanently installed units without built-in fuses, circuit breakers or similar protective devices, the supply circuit must be fused such as to provide suitable protection for the users and equipment.

5. Prior to switching on the unit, it must be ensured that the nominal voltage set on the unit matches the nominal voltage of the AC supply network.

   If a different voltage is to be set, the power fuse of the unit may have to be changed accordingly.

6. Units of protection class I with disconnectible AC supply cable and appliance connector may be operated only from a power socket with earthing contact and with the PE conductor connected.

7. It is not permissible to interrupt the PE conductor intentionally, neither in the incoming cable nor on the unit itself as this may cause the unit to become electrically hazardous.

   Any extension lines or multiple socket outlets used must be checked for compliance with relevant safety standards at regular intervals.

8. If the unit has no power switch for disconnection from the AC supply, the plug of the connecting cable is regarded as the disconnecting device. In such cases it must be ensured that the power plug is easily reachable and accessible at all times (length of connecting cable approx. 2 m). Functional or electronic switches are not suitable for providing disconnection from the AC supply.

   If units without power switches are integrated in racks or systems, a disconnecting device must be provided at system level.

9. Applicable local or national safety regulations and rules for the prevention of accidents must be observed in all work performed.

   Prior to performing any work on the unit or opening the unit, the latter must be disconnected from the supply network.

   Any adjustments, replacements of parts, maintenance or repair may be carried out only by authorized R&S technical personnel.

   Only original parts may be used for replacing parts relevant to safety (eg power switches, power transformers, fuses). A safety test must be performed after each replacement of parts relevant to safety.

   (visual inspection, PE conductor test, insulation-resistance, leakage-current measurement, functional test).

continued overleaf

10. Ensure that the connections with information technology equipment comply with IEC950 / EN60950.
11. Lithium batteries must not be exposed to high temperatures or fire.

    Keep batteries away from children.

    If the battery is replaced improperly, there is danger of explosion. Only replace the battery by R&S type (see spare part list).

    Lithium batteries are suitable for environmentally-friendly disposal or specialized recycling. Dispose them into appropriate containers, only.

    Do not short-circuit the battery.
12. Equipment returned or sent in for repair must be packed in the original packing or in packing with electrostatic and mechanical protection.
13. Electrostatics via the connectors may damage the equipment. For the safe handling and operation of the equipment, appropriate measures against electrostatics should be implemented.
14. Any additional safety instructions given in this manual are also to be observed.

Qualitätszertifikat

Sehr geehrter Kunde,

Sie haben sich für den Kauf eines Rohde & Schwarz-Produktes entschieden. Hiermit erhalten Sie ein nach modernsten Fertigungsmethoden hergestelltes Produkt. Es wurde nach den Regeln unseres Qualitätsmanagementsystems entwickelt, gefertigt und geprüft. Das Rohde & Schwarz-Qualitätsmanagementsystem ist u.a. nach ISO 9001 und ISO 14001 zertifiziert.

Certificate of quality

Dear Customer,

You have decided to buy a Rohde & Schwarz product. You are thus assured of receiving a product that is manufactured using the most modern methods available. This product was developed, manufactured and tested in compliance with our quality management system standards. The Rohde & Schwarz quality management system is certified according to standards such as ISO 9001 and ISO 14001.

Certificat de qualité

Cher client,

Vous avez choisi d'acheter un produit Rohde & Schwarz. Vous disposez donc d'un produit fabriqué d'après les méthodes les plus avancées. Le développement, la fabrication et les tests respectent nos normes de gestion qualité. Le système de gestion qualité de Rohde & Schwarz a été homologué, entre autres, conformément aux normes ISO 9001 et ISO 14001.

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1 Installing Option SMIQB21

Software option SMIQB21 has to be enabled by entering a key upon installation. An option label containing the installation key is supplied and has to be affixed to the rear of SMIQ for service and repair purposes.
As a prerequisite, SMIQ must be fitted with hardware option SMIQB20 (modulation coder).

<== Example

Fig. 1-1 Option label with example of installation key

Enabling the option (see Fig. 1-2)

- Switch on SMIQ.
- Call UTILITIES menu (select with rotary knob, confirm with [SELECT] key).
- Call INSTALL menu ==> [SELECT].
- Call OPTION TO INSTALL menu ==> [SELECT].
- Select option SMIQB21 BERT ==> [SELECT].
- Enter the 6-digit installation key shown on the option label into the INSTALLATION KEY line. Then press the [ENTER] key.
- You will receive a message confirming that the installation key has been verified and the option is installed.
- To make the option available, the unit has to be switched off and on again.
- Once the installation has been successfully completed, BER measurement can be selected from the main menu.

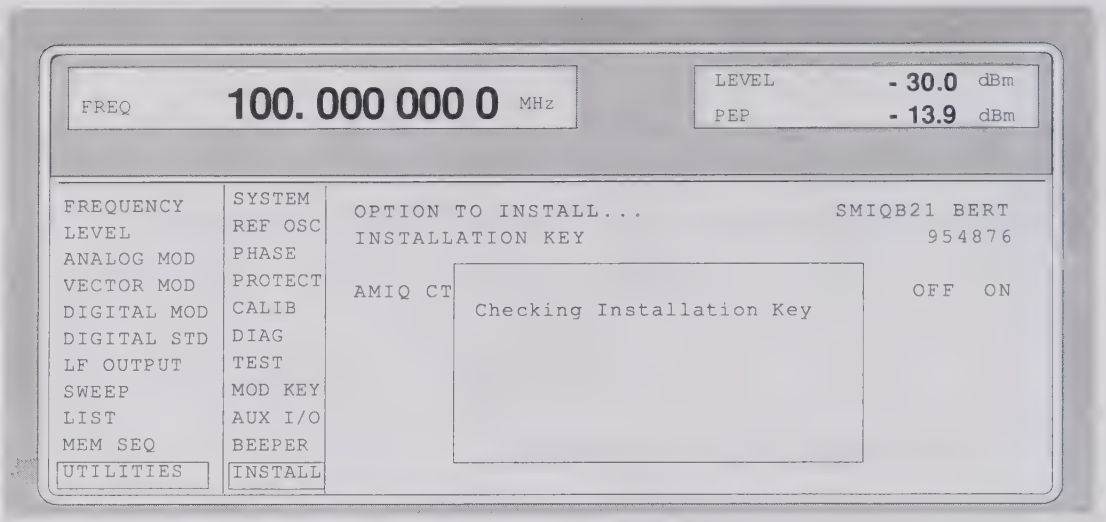


Fig. 1-2 Enabling option SMIQB21

Once the installation has been completed, the availability of the new option can be checked in the module list in the UTILITIES DIAG CONFIG menu.

1.1 Connector

The clock and data signals output by the DUT must have TTL level and are connected to the BER (bit error rate) input, a 9-contact SUB-D connector at the rear of the unit labelled BER. Pin assignment is as follows:

	SUB-D connector	**Adapter cable Order No. 1110.3551.00**
1,2,3,4,5	Ground	Screen
6	Bit clock input	CLOCK
7	Data input	DATA
8	Data enable input	DAT ENAB
9	Restart	RES

Polarity of clock and data signals, the PRBS polynomial used and the integration time can be set by manual or remote-control commands. The input signals are **not** terminated in the SMIQ but applied to ICs of type 74LVT14 via a 220 Ω resistor. A cable is supplied with the option. Its contacts are assigned to BNC connectors as shown in the above table.

2 Manual Operation

2.1 Measurement of the Bit Error Rate

Option SMIQB21 allows an evaluation of the signal demodulated and decoded by the DUT. For this purpose, a PRBS-modulated data sequence (PRBS = Pseudo Random Binary Sequence) is sent to the DUT. This data sequence can be generated continuously (by means of option SMIQB20) or in sections, in the latter case by means of option SMIQB60 using a loaded waveform.
The PRBS data sequence is decoded by the DUT and sent to the SMIQ in the form of clock and data signals. The SMIQ synchronizes to the known PRBS sequence and counts the bit errors.

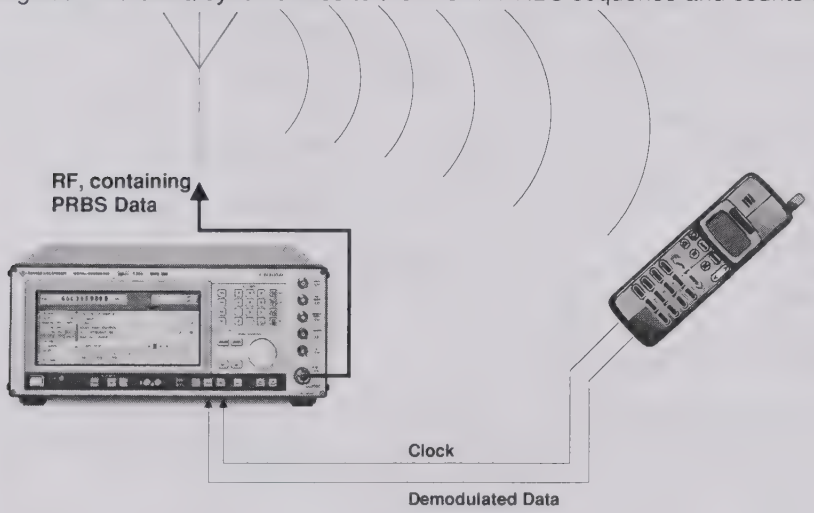


Fig. 2-1 Measurement of BER

Termination of a measurement can be induced by various criteria. With option SMIQB21, measurements can be stopped either manually or because of one of the following two criteria: a user-defined number of data bits has been transmitted or a maximum number of errors has been detected.

By means of the RESTART function (eg for IQ signals that are not generated continuously and therefore do not contain integer multiples of PRBS sequences) BER results can be integrated onto the (partial) sequences. In this way, long BER measurements can also be performed on short IQ signals (which normally do not allow BER measurement because the PRBS sequence is not continuous).

The BER measurement can also be performed separately (with data from another source).

2.2 Operating Menu

In the operating menu, the configuration for the BER measurement is made and the results are displayed.

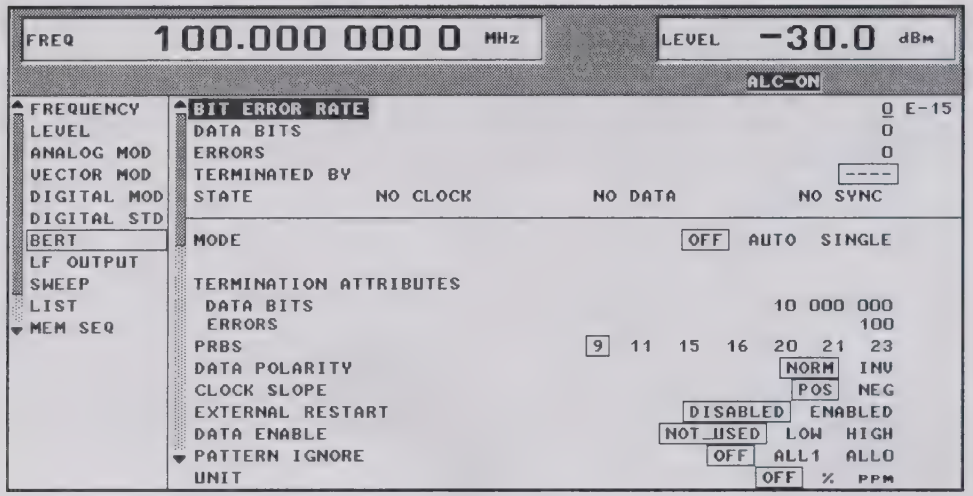


Fig. 2-2 Operating menu for BER measurement

In the upper section of the menu (display area), the measurement results are displayed together with the way in which they have been established, and additional information on the applied signal. In the lower section, settings can be made.

BIT ERROR RATE (BER) Cyclic display of the measured bit error rate, the ratio of detected errors to transmitted data bits.

DATA BITS Number of transmitted data bits.

ERRORS Number of detected errors.

TERMINATED BY The displayed measurement result was obtained as follows:

NUMBER OF DATA BITS	The defined number of data bits was reached.
NUMBER OF ERRORS	The defined number of errors was detected.
USER	The measurement was interrupted manually by the user.
----	Measurement in progress.

STATE

The status information described in the following tells the user whether the BER measurement is working. The STATE display signals the status of clock line, data line and synchronization. If the clock signal changes, CLOCK is indicated as status, otherwise NO CLOCK. The same applies to the data display DATA or NO DATA. NO DATA may be displayed because DATA ENABLE is not set to NOT USED or the data enable signal does not enable the data. SYNC indicates a successful attempt of PRBS synchronization by the analyzer. It is not before all three of CLOCK, DATA and SYNC are "active" that the measurement results are valid.

CLOCK	Change of clock signal.
NO CLOCK	No change of clock signal.
DATA	Change of data signal.
NO DATA	No change of data signal.
SYNC	Successful synchronization to PRBS.
NO SYNC	No synchronization.

The seven parameters listed above (data bits, error bits, error rate, attribute "terminated", attribute CLOCK, attribute DATA, attribute SYNC) are jointly polled by the IEC/IEEE bus query `:BERT:RES?`.

MODE

Setting for the BER measurement.

OFF Terminate measurement.

AUTO Continuous measurement of bit error rate. If one or both criteria for termination are fulfilled, a new measurement is initiated automatically. Depending on the settings made, a measurement may take considerable time. During the first measurement, intermediate results are displayed. For the measurements that follow, only the final results are shown. The parameters DATA BITS and ERRORS are continuously updated and indicate the relative values for the measurement in progress.

SINGLE Single measurement of bit error rate. During the measurement, SMIQ cyclically displays the updated values for rate, number of errors and number of data bits. If any one of the termination criteria (TERMINATION ATTRIBUTES [DATA BITS] and TERMINATION ATTRIBUTES [ERRORS]) is reached, the measurement is stopped. A single measurement is initiated only if the menu item EXECUTE SINGLE is selected.

IEC/IEEE-bus command
```
:BERT:STAT ON
:BERT:SEQ SING
```

EXECUTE SINGLE►

Initiates a single BER measurement. This menu item is only displayed if MODE = SINGLE is set.

IEC/IEEE-bus command `:TRIG:BERT:IMM`

TERMINATION ATTRIBUTES

DATA BITS Setting the termination criterion "Number of transmitted data bits".

IEC/IEEE-bus command `:BERT:SET:MCO <1>`

ERRORS Setting the termination criterion "Maximum number of detected errors".

IEC/IEEE-bus command `:BERT:SET:MERR <1>`

PRBS

Setting the period length of data: 9, 11, 15, 16, 20, 21, 23 bits.

Note: Data inversion for PRBS15 and PRBS23, which is contained in the standard, is performed automatically when the PRBS is selected. DATA POLARITY remains unaffected.

IEC/IEEE-bus command `:BERT:SET:TYPE PRBS9`

DATA POLARITY

Setting the data bit polarity.

NORM Normal polarity

INV Inverted polarity

IEC/IEEE-bus command `:BERT:SET:DATA NORM`

CLOCK SLOPE

Setting the clock edge polarity.

POS Rising edge

NEG Falling edge

IEC/IEEE-bus command `:BERT:SET:CLOC RIS`

EXTERNAL RESTART

Activating/deactivating an external restart of the BER measurement.

Note: *An enabled RESTART works always independently of PATTERN IGNORE or DATA ENABLE.*

DISABLED Deactivated

ENABLED Activated

IEC/IEEE-bus command `:BERT:SET:REST INT`

DATA ENABLE

Setting the polarity of the DUT's DATA ENABLE signal.

Note: *If the data are not enabled, the execution of the BER measurement is stopped completely. The identification circuit for PATTERN IGNORE as well as the PRBS generator of the BER measurement wait as long as data are not enabled. If the data are enabled, the measurement is continued.*

NOT USED Irrespective of the data enable signal applied, all data at the BERT data input are used for the BER measurement.

LOW Only the data applied at the BERT data input with a low-level data enable signal are used for the BER measurement.

HIGH Only the data applied at the BERT data input with a high-level data enable signal are used for the BER measurement.

IEC/IEEE-bus command `:BERT:SET:DEN OFF`

PATTERN IGNORE

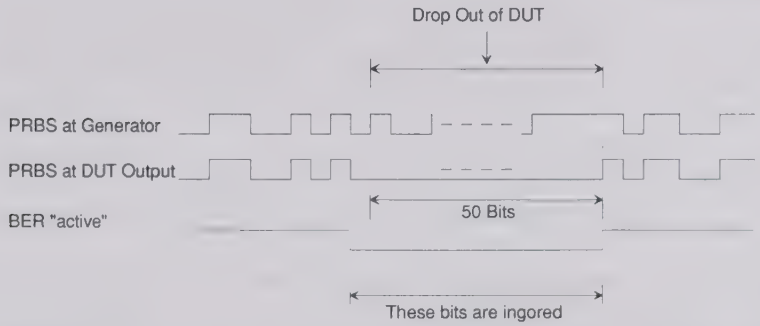
In the event of a so-called frame error (eg an error detected in the check sum), some mobile radio standards communicate a complete "0" or "1" frame to the BERT instead of the detected frame data. This is to signal to the BERT that this frame is not to be used for the BER measurement.

OFF	PATTERN IGNORE is not active.
ALL 1	Bit sequences consisting of 31 or more subsequent "1" data are not used (ie ignored) for the BER measurement.
ALL 0	Bit sequences consisting of 31 or more subsequent "0" data are not used (ie ignored) for the BER measurement.

IEC/IEEE-bus command `:BERT:SET:IGN OFF`

Notes:

- *While ignoring the bits, the PRBS generator for the BER measurement keeps running. Following the "0" or "1" sequence, the BER measurement is continued as if the ignored sequence had contained PRBS data.*
- *If PATTERN IGNORE is switched on, synchronization time is 32 bits longer.*
- *If PATTERN IGNORE and RESTART are active at the same time, the presence of the restart signal causes the measurement to stop **immediately**. None of the 32 bits within the PATTERN IGNORE detector is evaluated.*
- *If DATA ENABLE and PATTERN IGNORE are active at the same time, DATA ENABLE is given priority, ie bits that are not enabled are not examined for "0" or "1" sequences.*



Example 50 bits were set to "0" by the DUT. These 50 bits plus the preceding "0" are ignored in the measurement.

UNIT

Setting the unit for displaying the bit error rate.

OFF	No unit, decade values
%	Relative frequency in percent
ppm	Relative frequency in parts per million

IEC/IEEE-bus command `:BERT:UNIT OFF`

2.3 Signal Path and Waveform

See also section 1.1, "Connector".

Test setup

The signal is computed using one of the modulation sources listed above and then output by the SMIQ and sent to the DUT (device under test). The latter demodulates the source bits contained and returns them to SMIQ together with a transfer clock. In the SMIQ, the data bits are checked for errors. The total of the transmitted bits and the faulty bits are counted. The quotient of error bits/total bits is the BER.

PRBS data

To be able to detect faulty bits in a BER measurement, the data generation polynomial must be known. Data are calculated with the aid of so-called pseudo-random binary sequences (PRBS). These are quasi-random bit sequences which are repeated according to the selected polynomial.

An advantage of the PRBS data is that the bit error detector has only to know the polynomial but not the total sequence. Furthermore, the analysis can be started anywhere in the bit stream, ie the bit-stream source and the analyzer need not be synchronized.

Transfer clock

Should the DUT not provide a transfer clock, the bit clock can be taken from the output connector PAR-DATA for the generation of the signal using option SMIQB11 (DGEN). If AMIQ is used as the IQ source, a marker channel may be programmed as clock output. However, the clock-to-data ratio is to be observed.

2.4 Test Method

Generation of PRBS data

PRBS data are generated with the aid of a shift register with feedback points determined by the polynomial. A random start status yields one subsequent state. The start status and therefore the subsequent status occur only once in the whole sequence.

Feedback of data stream

If the shift register is filled with a data sequence at the beginning of a measurement and the register is then switched from "filling" to "feedback", the register generates the same data sequence as it expects to receive. Faulty bits can thus be identified and counted by comparing the received data to the results obtained from the shift register.

This method has the advantage that the analyzer can be used separately from signal generation (logically and with respect to time). Consequently, delays caused by the DUT, the use of other PRBS sources and transmission over long distances with spatially separated transmitter and receiver, do not cause any problems.

Errors in start status

If a bit error is already present in the start status (faulty bits are not detected during filling), the shift register starts from an incorrect position in the data sequence. As a result all subsequent states will be faulty. Since, statistically, every second bit is faulty, the BER will be about 50%. In this case the measurement is started again automatically, without the user realizing.

BER measurement with uninterrupted repetition of the random sequence

The (non-integrating) BER measurement operates on the basis of random sequences that are run continuously. These sequences are either generated continuously or by cyclic output of a stored sequence, with the number of encoded bits being an integer multiple of the length of the random sequence. The length of the random sequence is 2 to the power of the degree of the polynomial less 1, ie PRBS9 has a length of 511 (2^9 equals 512 less 1).

This type of BER measurement is selected by either setting External Restart to DISABLED or by issuing the IEC/IEEE-bus command `:BERT:SET:REST INT`. The CLOCK and DATA lines are sufficient for this measurement.

The data to be analyzed are interrupted by other data

The data bits contain data like sync, preambles, other channels, etc in addition to the PRBS data. To mark the data to be evaluated, a DAT ENABle signal has to be sent with the data. Either this DAT ENABle signal is generated by the DUT or an additional channel of the IQ source is used (eg marker channel of AMIQ).

The BER measurement in the SMIQ has to be adjusted for the use of a DAT ENABle signal; this is done by setting the required polarity in the menu or by means of IEC/IEEE-bus command (`:BERT:SET:DEN Low|High`). Data Enable = high means that data are only counted by the DUT and subjected to the BER measurement if the data enable input is set to 1.

BER measurement with interrupted random sequence - integrating BER measurement

Due to the type of data, oversampling and the finite memory length of SMIQ (option SMIQB60) or AMIQ, it may happen that the generated random sequence is not cyclically repeated at the memory wrap-around but has a break at this point. In a normal BER measurement operating exclusively with CLOCK and DATA signals, a break of this kind would lead to approx. 50% faulty bits due to the loss of synchronization.

A random sequence with a break can be processed by means of the **integrating BER measurement** and is switched on in the menu under EXTERNAL RESTART (or by the remote-control command `BERT:SET:REST EXT`). The BER measurement is to be stopped in time and then restarted at the beginning of the data sequence. The measurement is stopped and started via a signal at the RES input (pin 9 of SUB-D connector): A transition from logic 0 to 1 causes a partial result to be generated and the measurement to be stopped. A transition from 1 to 0 starts the measurement for the next sub-interval. This measurement is synchronized anew.
This input is best connected to an AMIQ marker channel or the SMIQ trigger output, with a single 1 encoded both at the start and at the end of the data sequence. This causes the BER measurement to stop briefly at memory wrap-around (the break) and start again. The partial results are integrated.

When the signals are interrupted by other data (eg preambles), these data will normally cause bit errors. The BER measurement for these data can then be interrupted using the data enable input .

In the integrating BER measurement, partial BER results are added up (controlled by a signal at the RES input) until the predefined total number of data or error bits is attained or exceeded.

Note: *Since the test hardware can be programmed flexibly, other bit error measurement techniques such as comparison with the output pattern, masking of certain time and data ranges, are also possible. In this matter, please contact your nearest R&S representative.*

2.4.1 PRBS Polynomials

For generating and testing the PRBS, a shift register with feedback is used. The feedback depends on the type of polynomial used. The sequence length of a generator is the result of $2^n - 1$, n being the degree of the polynomial.

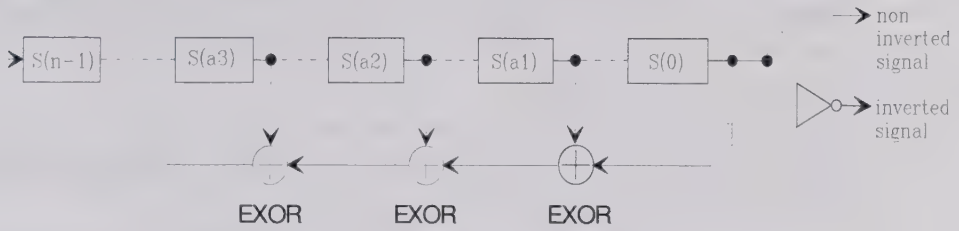


Fig. 2-3 PRBS polynomials

PN generator	N	a1	a2	a3	Output	acc. to standard
PN9	9	4	-	-	non-inverted	ITU-T Rec. O.153 Fascicle IV.4
PN11	11	2	-	-	non-inverted	ITU-T Rec. O.152 Fascicle IV.4
PN15	15	1	-	-	inverted	ITU-T Rec. O.151 Fascicle IV.4
PN16	16	5	3	2	non-inverted	--
PN20	20	3	-	-	non-inverted	ITU-T Rec. O.153 Fascicle IV.4
PN21	21	2	-	-	non-inverted	--
PN23	23	5	-	-	inverted	ITU-T Rec. O.151 Fascicle IV.4

2.4.2 Measurement Result, Accuracy, Measurement Time

Value range

Measurement results for the bit error rate (ie the quotient of error bits and total bits) are usually found between 10^{-2} and 10^{-9}. This means that a large number of bits may have to be checked before a faulty bit is detected. Because of the large number of bits involved the measurement time is usually very long.

Since 32-bit-wide counters are used for the total bits and the error bits, the maximum measurement time is 4.29×10^9 bits.

Statistics

The BER measurement measures statistical bit errors, ie errors which do not occur at regular intervals but at random. Although a single measurement determines the exact number of errors in the measured interval, a statistically reliable BER can only be obtained when a sufficient number of errors occurs in the observed interval. Only this ensures that the single BER measurement result approaches the true error rate with high probability .

Termination criteria

To keep the measurement time short with low and high bit error rates, two termination criteria have been defined in SMIQ for the BER measurement.

- Criterion 1: Total number of bits
  The measurement is terminated when the specific number of data bits is reached. Due to this criterion the BER measurement is reliably stopped after the specified number of bits even if no error or only a few errors were detected; the measurement result is not statistically reliable (few bit errors).
- Criterion 2: Number of errors
  The measurement is terminated when the specified number of bit errors is detected. With this criterion, the measurement is rapidly terminated when high bit error rates occur. Since a great number of errors is counted, the measurement result is statistically reliable.

The two criteria are used together. The criterion which finally yields a valid result is indicated in the results screen ("Measurement terminated by...").

Interruption of measurement

At the end of a measurement, the restart of a new one is delayed until the first measurement result has been queried with `:BERT:RES?`. The resulting brief measurement interruption is irrelevant because the subsequent measurement will be synchronized within 24 data bits.

2.4.3 Possible Problems with BER Measurement and Related Solutions

Fault	Possible cause	Fault description/remedy
BER measurement does not synchronize	No signals received from DUT or the signal level is not correct.	➢ Check displays for activity at BER measurement inputs. If a status is displayed (Clock, Data, Sync) for a line, there is activity.
	The selected PRBS is not correct.	Normally, the PRBS on which the data are based is used as the default setting. If the PRBS is changed, the BER measurement cannot synchronize to the data (because the polynomial is not correct).
	A wrong clock edge is used, which violates setup or hold times.	➢ Check the bit clock signal, the data signal and the data enable signal, if any, on an oscilloscope. The fault may also be caused by reflections on the clock line, which switch the data signal twice into the BER measurement, eg on lines without termination. The SMIQ input is **not** terminated.
	Incorrect polarity of data signal (or data enable signal).	In this case the PRBS cannot synchronize. Note that an inversion of the output signal specified for some cases by the PRBS standard is performed automatically upon PRBS selection. Manual inversion of the data signal is therefore not required.
	A bit error occurs during synchronization (nine data bits with PRBS9)	The BER measurement is started at a wrong position so that about 50% of the subsequent data bits are identified as faulty.
No clock received from DUT	When testing RF components, clock recovery is not available. An external clock is however required for clocking the data during the BER measurement	Instead of a clock recovery circuit, the bit clock at the PAR-DATA connector of the SMIQ may be possibly used as a replacement. This is possible if DGEN (SMIQB11) is used as a data source. However, this bit clock is not possible with all modulation types. Also, the delay between data and clock has to be observed.
Measured BER too high	The data are clocked with the wrong edge and/or the eye aperture of the data is not optimally met.	➢ Check the clock/data relationship by means of an oscilloscope and set optimum timing.
	BER measurement does not synchronize	If data that are not cyclically continued (ie when a break occurs at the memory wrap-around), the measurement will identify about 50% of the bits as faulty after the wrap-around. Make sure the measurement is started optimally at the beginning of the sequence by means of a signal on the REStart line (see: "BER measurement with interrupted random sequence – integrating BER measurement" in section 2.4, "Test Method").

3 Remote Control

3.1 Description of IEEE/ IEC Bus Commands – Source:BERT Subsystem

Command	Parameter	Default Unit	Remark
[:SOURce]			
:BERT			
:STATe	ON | OFF		
:SEQuence	AUTO | SINGle		
:SETup			
:MCOunt	1 to 4294967294		
:MERRor	1 to 4294967294		
:TYPE	PRBS9 | PRBS11 | PRBS15 | PRBS16 | PRBS20 | PRBS21 | PRBS23		
:DATA			
[:POLarity]	NORMal | INVerted		
:CLOCk			
[:POLarity]	RISing | FALLing		
:RESTart	INTernal | EXTernal		
:DENable	OFF | LOW | HIGH		
:MASK	OFF | LOW | HIGH		Alias
:IGNore	OFF | ONE | ZERO		
:UNIT	OFF | PCT | PPM		
:STARt	(without)		
:STOP	(without)		
:RESULT?			Query only

:BERT:STATe ON | OFF

This command switches the bit error rate test on or off. The command `:BERT:STARt` sets the status internally to `ON`, while the command `:BERT:STOP` sets it to `OFF`.

Example: `:BERT:STAT ON` *RST value is OFF

:BERT:SEQuence AUTO | SINGle

This command switches between continuous (`AUTO`) and single measurement (`SINGle`). A single measurement is terminated once the set number of data bits or error bits is reached. The continuous measurement is a sequence of automatically started single measurements.

By means of the command `:BERT:STARt`, the status is internally set to `AUTO`.

Example: `:BERT:SEQ SING` *RST value is AUTO

:BERT:SETup:MCOunt 1 to 4294967294

This command sets the total number of data bits to be measured (data excluded by `:BERT:SETup:DENable` do not count). When the internal data counter reaches or – in integrated BER test – exceeds this number, the single BER measurement is terminated. If this is followed by the query `:BERT:RES?`, SMIQ signals with the fourth result that a BER measurement has been completed. This fourth result then has the value 1.

Valid value range: 1 to 4294967295 (2^{32}-1)

Example: `:BERT:SET:MCO 1e6` *RST value is 10.000.000

:BERT:SETup:MERRor 1 to 4294967294

This command sets the number of error bits to be measured. When the internal bit error counter reaches or – in integrating BER test – exceeds this number, the SMIQ responds to a `:BERT:RES?` query by signalling with the fourth result = 1 that a single BER measurement has been terminated.

Valid value range: 1 to 4294967295 (2^{32}-1)

Example: `:BERT:SET:MERR 100` *RST value is 100

:BERT:SETup:TYPE PRBS9 | PRBS11 | PRBS15 | PRBS16 | PRBS20 | PRBS21 | PRBS23

With this command, various sequence lengths can be set for the pseudo-random bit sequence. The data generated by the PRBS generator are used as a reference.

Example: `:BERT:SET:TYPE PRBS15` *RST value is PRBS9

:BERT:SETup:DATA[:POLarity] NORMal | INVerted

This command defines the polarity of the external data signal.

NORMal: High level stands for a logic 1, low level for a logic 0.

INVerted: Low level stands for a logic 1, high level for a logic 0.

Example: `:BERT:SET:DATA INV` *RST value is NORM

:BERT:SETup:CLOCk[:POLarity] RISing | FALLing

This command defines which edge of the externally fed clock signal is active.

Example: `:BERT:SET:CLOC FALL` *RST value is RIS

:BERT:SETup:RESTart INTernal | EXTernal

INTernal The reset signal for the BER test is generated internally by the program. This setting is suited for random sequences fitting cyclically into the SMIQ memory and therefore allowing an uninterrupted repetition of the random sequence.

EXTernal If the random sequence cannot be continued without interruption at memory wrap-around, the BER test has to be stopped in time and then restarted at the beginning of the data sequence. The measurement is stopped and started via a 0-1-0 edge at the restart input. Partial BER results (data and error bits) are added up until the predefined total number of data or error bits is reached or exceeded. These partial results are not affected by a restart.

Example: `:BERT:SET:RES EXT` *RST value is INT

:BERT:SETup:DENable OFF | LOW | HIGH

The SMIQ has an input (data enable) allowing the temporary suspension of the BER test for processing data bursts or data interrupted by other data. This command configures this input.

OFF Any signal applied to the input is ignored; all data are used for the BER measurement.

HIGH If a high level signal is applied to the input, its data bits are counted and the bit errors detected and counted. If a low level signal is applied, the measurement is interrupted.

LOW If a low level signal is applied to the input, its data bits are counted and the bit error detected and counted. If a high level signal is applied, the measurement is interrupted.

Example: `:BERT:SET:DEN HIGH` *RST value is OFF

:BERT:SETup:MASK OFF | LOW | HIGH

This command is equivalent (alias) to the command `:BERT:SETup:DENable` described above.

Example: `:BERT:SET:MASK HIGH` *RST value is OFF

:BERT:SETup:IGNore OFF | ONE | ZERO

This command determines what to do with faulty data (frame errors) that were set to 0 or 1.

OFF Pattern Ignore is not active.

ONE Bit sequences consisting of 30 or more subsequent "1" data are not used (ie ignored) for the BER test.

ZERO Bit sequences consisting of 30 or more subsequent "0" data are not used (ie ignored) for the BER measurement.

Example: `:BERT:SET:IGN ONE` *RST value is OFF

:BERT:UNIT OFF | PCT | PPM

This command sets the unit for displaying the error rate. It is only for display on SMIQ; it has no effect on results queried by `:BERT:RES?`.

Example: `:BERT:SET PCT` *RST value is OFF

:BERT:STARt

This command starts a bit error rate test. The command `:BERT:STAT` is set to `ON` and `BERT:SEQ` to `AUTO`.

Example: `:BERT:STAR`

:BERT:STOP

The command stops an ongoing bit error rate test. If no measurement is in progress, this command has no effect. `:BERT:STAT` is set to `OFF`.

Example: `:BERT:STOP`

:BERT:RESult?

This query refers to the result of the most recent BER measurement. The response consists of seven results separated by commas. In the first measurement following the start, intermediate results for the number of data bits, error bits and error rate are also queried. In the following measurements (only for :BERT:SEQ AUTO), only the final results of each single measurement are queried.

Example: :BERT:RES?

Response: "10000,5,5E-4,1,1,1,1"

Result: 1 ,2,3 ,4,5,6,7

Result 1	Number of data bits from current query.	
Result 2	Number of error bits from current query.	
Result 3	Error rate. If no termination criterion has been reached since the beginning of the BER test, the current quotient of "Number of error bits" and "Number of data bits" is entered. As soon as at least one final result has been reached in continuous measurement, the most recent final result is entered. This means the error rate displayed changes less rapidly.	
Result 4	1	A BER measurement has been terminated, ie the number of data bits or error bits predefined by commands :BERT:SET MCOunt <n> or :BERT:SET MERRor <n> is reached, or the measurement was stopped by the command :BERT:STOP.
	0	The BER measurement has not been terminated.
Result 5	1	Following the start of a BER measurement (by the command :BERT: STARt), an edge was detected on the clock line.
	0	The clock line is not active.
Result 6	1	Following the start of a BER measurement (by the command :BERT: STARt), a data change edge was detected on the data line. This data change only refers to clocked data. If there is no clock, no data change is detected.
	0	The data line is not active.
Result 7	1	The BER measurement is synchronized, ie both clock and data line are active and the "Number of error bits" to "Number of data bits" ratio is better than 0.1, so the measurement result can be assumed to be realistic.
	0	The BER measurement is not synchronized.

4 Performance Test

4.1 Test Instructions BERT

Test assembly

➢ For the functional test, the inputs and outputs of this interface are connected via a connector (Operating manual SMIQ, Table 5-1, item 27).

Measurement

➢ SMIQ settings
UTILITIES/TEST/TEST MOD BERT

⇨ Error messages may not occur.

4.2 Performance Test Report

For nominal data and limit values refer to the data sheet supplied with the instrument.

Characteristic	Min.	Actual	Max.	Unit